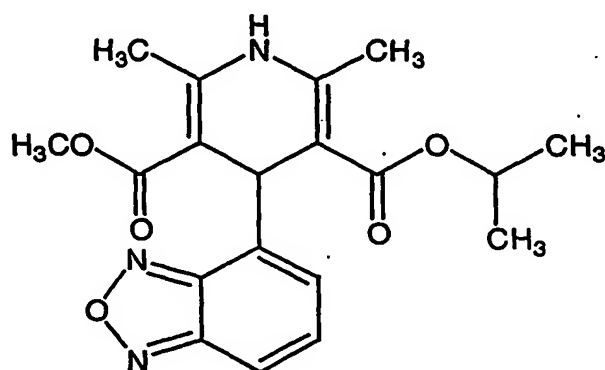


## 5 FIELD OF THE INVENTION

The present invention relates to an improved method for the manufacture of Isradipine, 4-(4-Benzofurazanyl)-1,4-dihydro-2,6-dimethyl-3,5-pyridinedicarboxylic acid methyl 1-methylethyl ester. More particularly the present invention relates to the process for the manufacture of Isradipine of substantially high purity and relatively free from the symmetrical ester impurities.

## BACKGROUND OF THE INVENTION

Isradipine is 4-(4-Benzofurazanyl)-1,4-dihydro-2,6-dimethyl-3,5-pyridinedicarboxylic acid methyl 1-methylethyl ester having the chemical structure of formula (I).

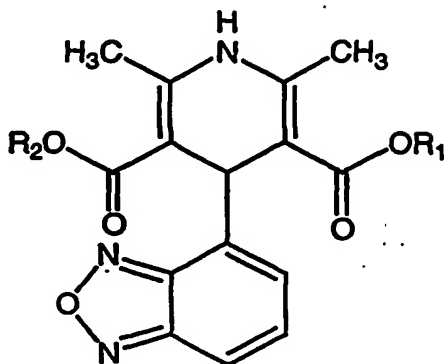


(I)

Isradipine is therapeutically indicated for treating cardiovascular diseases. The cardiovascular diseases include angina, pectoris, hypertension and congestive heart failure. It is also used to treat high blood pressure.

Isradipine was disclosed in the German specification DE 2949491 and US patent Nos. 4466972 and 4567271. DE 2949491 describes the general procedure to prepare 1,4-dihydropyridine derivatives. US 4466972, GB02103203A, LU 0088342A9, EP 0000150A1, EP 0000150B1, AU 0538515B2 and other related patents describe the general method for the preparation of Benzoxadiazoles and

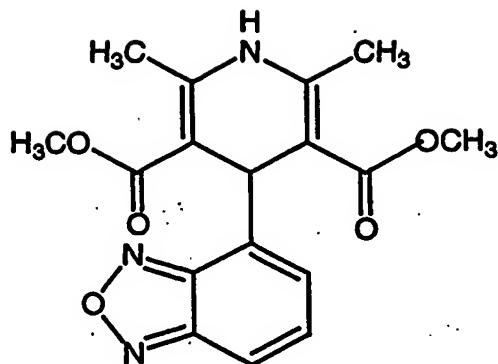
- 5 their derivatives of general formula (II). These references in its entirety is hereby incorporated by reference into this application.



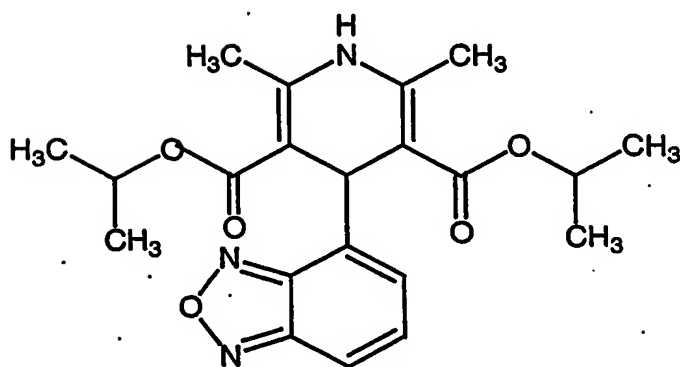
10 (II)

Where in  $R_1$  is  $-\text{CH}_3$  and  $R_2$  is  $-\text{CH}(\text{CH}_3)_2$  it refers to Isradipine of formula (I). When  $R_1$  and  $R_2$  are not identical the general procedures described in these patent specifications produces a mixture of isomers of formula (II). These procedures for the preparation of Isradipine is characteristic of formation of the isomeric impurities, 1) 4-(4-Benzofurazanyl)-1,4-dihydro-2,6-dimethyl-3,5-pyridinedicarboxylic acid di-methyl ester of formula (III) and 2) 4-(4-Benzofurazanyl)-1,4-dihydro-2,6-dimethyl-3,5-pyridinedicarboxylic acid di-1-methylethyl ester of formula (IV) along with Isradipine.

The US patent 4466972 describes the preparation of compounds of general formula (II) by refluxing 2, 1, 3-benzoxadiazole-4-carboxaldehyde, keto ester and concentrated ammonia or a  $\beta$ -amino ester in presence of ethanol, followed by evaporation and purification by chromatography.



(III)



(IV)

These symmetrical ester isomers (III) and (IV) are difficult to separate from the Isradipine and the separation is effected only by a chromatographic purifications. The drawback with the procedures described in these patents is that it is very difficult to produce the product in commercial quantities as it involves the purification of the product by chromatographic separations.

A single step process for the preparation of Isradipine was described in CH 661270. This procedure involves first reacting 2,1,3-benzoxadiazole-4-carboxaldehyde with isopropyl acetoacetate in the presence of catalytic quantities of acetic acid and piperidine in refluxing toluene, and further reacting it with methyl- $\beta$ -aminocrotonate. The Isradipine formed in the reaction mixture was then separated by toluene distillation followed by cyclohexane treatment. The crude product obtained was then crystallised from ethanol to get Isradipine. When we

5 have repeated this process in our laboratory we got the Isradipine with substantially higher amount of symmetrical ester isomers ( III ) and ( IV ) are present in the product. Removal of these symmetrical ester isomers is very difficult even after several repurifications from ethanol.

#### OBJECTS OF THE INVENTION

10 The object of the present invention is to provide an improved method for the manufacture of Isradipine, 4-(Benzofuranzayl)-1, 4-dihydro - 2, 6 - dimethyl - 3, 5 - pyridine dicarboxylic acid methyl-1-methylethyl ester.

It is a further object of the instant invention to obtain Isradipine of substantially high purity and relatively free from the symmetrical ester impurities, 15 capable of being used to product commercial quantities of Isradipine pharmaceutical grade.

#### SUMMARY OF THE INVENTION

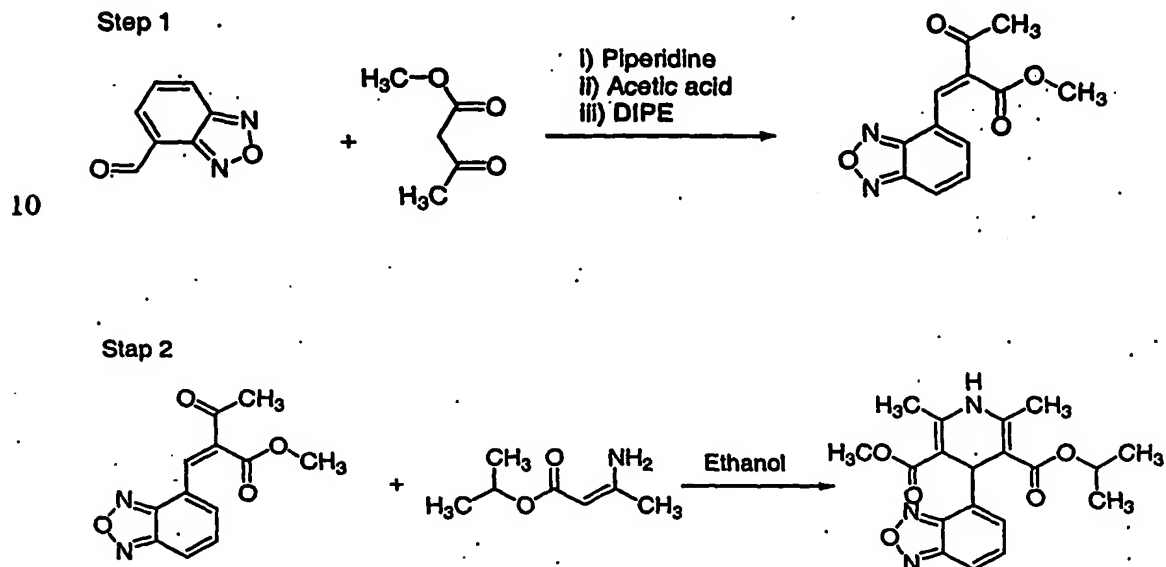
To achieve the afore-mentioned objects, the present invention provides for a process for the manufacture of the Isradipine which, involves two steps. In the 20 first step 2,1,3-benzoxadiazole-4-carboxaldehyde is reacted with methyl acetoacetate in the presence of acetic acid and piperidine in diisopropyl ether. The product 2-acetyl-3-benzofurazan-4-yl-acrylic acid methyl ester is isolated and purified to get substantially high purity product with less than 0.3% 2,1,3-benzoxadiazole-4-carboxaldehyde content present in the purified product. In the 25 second step the purified intermediate 2-acetyl-3-benzofurazan-4-yl-acrylic acid methyl ester is reacted with isopropyl- $\beta$ -aminocrotonate in ethanol at 25 to 35°C. The crude Isradipine is crystallised from ethanol to get pure Isradipine having substantially higher purity and containing lower amount of the symmetrical ester isomers ( III ) and ( IV ).

#### 30 DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to an improved method for the manufacture of Isradipine, 4-(4-Benzofurazanyl)-1,4-dihydro-2,6-dimethyl-3,5-pyridinedicarboxylic acid methyl 1-methylethyl ester. More particularly the present invention relates to the process for the manufacture of Isradipine of substantially 35 high purity and relatively free from the symmetrical ester impurities.

5

The present process for the manufacture of the Isradipine involves two steps. The following scheme 1 illustrates a reaction sequence of the present invention for the manufacture of the Isradipine.



In the first step, 2,1,3-benzoxadiazole-4-carboxaldehyde is reacted with  
 15 methyl acetoacetate in the presence of acetic acid and piperidine in diisopropyl ether. The reaction is carried out in diisopropyl ether under reflux with simultaneous removal of water formed during the reaction. Removal of the water from the reaction mixture enables the reaction to proceed at a faster rate. The reaction is completed at the end of theoretical amount of water removal from the  
 20 reaction mixture. The completion of the reaction is determined by qualitative HPLC analysis. In this reaction methyl acetoacetate 0.9 to 1.1 mol is used for every 1.0 mol of 2,1,3-benzoxadiazole-4-carboxaldehyde, preferably 0.95 to 1.0 mol methyl acetoacetate is used for every 1.0 mol of 2,1,3-benzoxadiazole-4-carboxaldehyde. Acetic acid and piperidine are used in catalytic amount, preferably  
 25 acetic acid 0.25 to 0.30 mol and piperidine 0.08 to 0.06 mol is used for every 1.0 mol of 2,1,3-benzoxadiazole-4-carboxaldehyde. This reaction goes to completion after 8 to 12 hr at reflux. The reaction mixture is then washed with dilute hydrochloric acid, followed by dilute sodium bicarbonate solution and followed by

5 water. The crude product 2-acetyl-3-benzofurazan-4-yl-acrylic acid methyl ester is then obtained by distillation of diisopropyl ether under vacuum.

The crude product is then crystallised from diisopropyl ether to get the pure 2-acetyl-3-benzofurazan-4-yl-acrylic acid methyl ester having purity more than 99% (both cis and trans isomers), and it contained less than 0.3% 2,1,3-benzoxadiazole-  
10 4-carboxaldehyde by HPLC. In a preferred embodiment of the present invention, the crude product is crystallized from ethanol to get substantially pure 2-acetyl-3-benzofurazan-4-yl-acrylic acid methyl ester as it allows for obtaining better yields.

In the second step, 2-acetyl-3-benzofurazan-4-yl-acrylic acid methyl ester is reacted with isopropyl- $\beta$ -aminocrotonate in ethanol at 25 to 40°C and preferably at  
15 25 to 35°C. In this reaction isopropyl- $\beta$ -aminocrotonate 0.9 to 1.05 mol is used for every 1.0 mol of 2-acetyl-3-benzofurazan-4-yl-acrylic acid methyl ester, preferably 0.95 to 1.0 mol is used for every 1.0 mol of 2-acetyl-3-benzofurazan-4-yl-acrylic acid methyl ester. This reaction goes to the completion in 6 to 8 hr at 30°C.

Ethanol is removed from the reaction mixture at less than 50°C under vacuum to  
20 get the concentrate containing Isradipine. The concentrate is dissolved in ethyl acetate and washed with water to remove a little amount of the unknown water soluble impurities formed in this reaction. The water washed ethyl acetate layer is then concentrated at less than 50°C under reduced pressure. The concentrate is then dissolved in ethanol at 65 to 80°C and cooled to get the Isradipine crystallised  
25 from the solution. The product is optionally recrystallised from ethanol to get pure Isradipine having typical purity more than 99.4% and the impurity ( III ) less than 0.3% and impurity ( IV ) less than 0.2% and other unknown impurity total less than 0.1% by HPLC analysis.

The present invention will now be described in more detail by way of  
30 examples, which should not be construed as limiting the invention thereto.

#### Example 1

##### Preparation of 2-acetyl-3-benzofurazan-4-yl-acrylic acid methyl ester

Suspended 2,1,3-benzoxadiazole-4-carboxaldehyde (50 g, 0.33 mole) in diisopropyl ether (1300 ml) and added methyl acetoacetate (38 g, 0.32 mole);  
35 piperidine (2 g) glacial acetic acid (6 g) in to the suspension one after another.

- 5     Refluxed the reaction mixture at 70 °C with continuous water separation.  
Removed sample from the reaction mixture and analysed the samples by  
qualitative HPLC. Washed the reaction mixture with hydrochloric acid (~ 3.5 wt  
%, 250 ml), sodium bicarbonate solution (~ 10 wt %, 250 ml) and water (250 ml,  
100 ml). Dried the organic layer over sodium sulphate (25 g) and then distilled  
10   diisopropyl ether under vacuum to get crude 2-acetyl-3-benzofurazan-4-yl-acrylic  
acid methyl ester (yield 70g, HPLC purity 93.4%)..

#### Example 2

##### Purification of 2-acetyl-3-benzofurazan-4-yl-acrylic acid methyl ester

- Added diisopropyl ether (100 ml) in to the concentrate containing crude 2-  
15   acetyl-3-benzofurazan-4-yl-acrylic acid methyl ester (70 g) as obtained in Example  
1, and heated to 50°C and then cooled to 30°C and filtered. The product washed  
with diisopropyl ether and repurified from diisopropyl ether and dried at 40°C  
under vacuum to obtain 50 g titled product (yield = 61%, purity 99.2%, and 0.12%  
2,1,3-benzoxadiazole-4-carboxaldehyde by HPLC)

#### 20   Example 3

##### Purification of 2-acetyl-3-benzofurazan-4-yl-acrylic acid methyl ester

- Added ethanol (160 ml) into the concentrate containing crude 2-acetyl-3-  
benzofurazan-4-yl-acrylic acid methyl ester (70 g) as obtained in Example 1, and  
heated to 45 to 50°C and stirred for 30 minutes. The content is then cooled to 0  
25   to 5°C and filtered, the product washed with chilled ethanol (20 ml). The product  
is dried at 40°C under vacuum to obtain 63g titled product (2,1,3-benzoxadiazole-  
4-carboxaldehyde content is 0.21% by HPLC)

#### Example 4

- Preparation of Isradipine using crude 2-acetyl-3-benzofurazan-4-yl-acrylic  
30   acid methyl ester

- Dissolved the crude 2-acetyl-3-benzofurazan-4-yl-acrylic acid methyl ester  
obtained in example – 1 (25 g, 0.10 mol) in absolute ethanol (375 ml) and added in  
to the solution isopropyl-β-aminocrotonate (13.15 ml, 0.09 mol). Stirred the  
reaction mixture under nitrogen atmosphere at 25-28 °C for 7 hr. Removed  
35   sample from the reaction mixture and analysed the sample by qualitative HPLC.

- 5 Distilled ethanol from the reaction mixture under vacuum at 50°C. Dissolved the residue in ethyl acetate (235 ml) and washed twice with water (90 ml). Dried the organic layer over sodium sulphate and distillation under vacuum at 50 °C. Dissolved the concentrate in ethanol (65 ml) at 70°C and slowly cooled to 5°C to get the product crystallised. Filtered the product and washed with pre cooled
- 10 ethanol (25 ml). Recrystallised the product from ethanol (60 ml) and dried at 70°C under vacuum to obtain Isradipine (yield = 20 g, purity = 98.2% and Impurity III = 0.64%, Impurity IV = 0.51% by HPLC)

#### Example 5

- Preparation of Isradipine using purified 2-acetyl-3-benzofurazan-4-yl-acrylic acid methyl ester
- 15

- Dissolved 2-acetyl-3-benzofurazan-4-yl-acrylic acid methyl ester (25 g, 0.10 mol) in absolute ethanol (375 ml) and added in to the solution isopropyl- $\beta$ -aminocrotonate (13.15 ml, 0.09 mol). Stirred the reaction mixture under nitrogen atmosphere at 25-28 °C for 5 hr. Removed sample from the reaction mixture and
- 20 analysed the sample by qualitative HPLC. Distilled ethanol from the reaction mixture under vacuum at 50°C. Dissolved the residue in ethyl acetate (235 ml) and washed twice with water (90 ml). Dried the organic layer over sodium sulphate and distillation under vacuum at 50 °C. Dissolved the concentrate in ethanol (65 ml) at 70°C and slowly cooled to 5°C to get the product crystallised. Filtered the product.
- 25 and washed with pre cooled ethanol (25 ml). Recrystallised the product from ethanol (60 ml) and dried at 70°C under vacuum to obtain 25 g Isradipine (yield = 67%, purity 99.5%, Impurity III = 0.20%, and Impurity IV = 0.12% by HPLC)

#### Example 6

- Preparation of Isradipine using purified 2-acetyl-3-benzofurazan-4-yl-acrylic acid methyl ester
- 30

- Dissolved the purified 2-acetyl-3-benzofurazan-4-yl-acrylic acid methyl ester, obtained in example – 3 (25 g, 0.10 mol) in absolute ethanol (375 ml) and added in to the solution isopropyl- $\beta$ -aminocrotonate (13.15 ml, 0.09 mol). Stirred the reaction mixture under nitrogen atmosphere at 25-28 °C for 5 hr. Removed
- 35 sample from the reaction mixture and analysed the sample by qualitative HPLC.



5 Distilled ethanol from the reaction mixture under vacuum at 50°C. Dissolved the residue in ethyl acetate (235 ml) and washed twice with water (90 ml). Dried the organic layer over sodium sulphate and distillation under vacuum at 50 °C. Dissolved the concentrate in ethanol (65 ml) at 70°C and slowly cooled to 5°C to get the product crystallised. Filtered the product and washed with pre cooled  
10 ethanol (25 ml) and dried at 70°C under vacuum to obtain 30g Isradipine (purity = 99.4%, Impurity III = 0.22%, and Impurity IV = 0.11% by HPLC).

Throughout this application, various publications are referenced. The disclosures of these publications in their entireties are hereby incorporated by reference into this application in order to more fully describe the state of art to  
15 which this invention pertains.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the  
20 invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.